Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

AD-A238 723

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION	
1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY	
3. DISTRIBUTION/AVAILABILITY OF REPORT	Approved for public release; distribution unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	
5. MONITORING ORGANIZATION REPORT NUMBER(S)	DAAL03-87-K- 0142
6a. NAME OF PERFORMING ORGANIZATION	California Institute of Technology
6b. OFFICE SYMBOL (If applicable)	
7a. NAME OF MONITORING ORGANIZATION	U. S. Army Research Office
6c. ADDRESS (City, State, and ZIP Code)	Pasadena, California 91125
7b. ADDRESS (City, State, and ZIP Code)	P.O. Box 12211 Research Triangle Park, NC 27709-2211
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	U. S. Army Research Office
8b. OFFICE SYMBOL (If applicable)	
9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	ARO 24876.5-PH
8c. ADDRESS (City, State, and ZIP Code)	P.O. Box 12211 Research Triangle Park, NC 27709-2211

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO.
DAAL03	87	K	0142

11. TITLE (Include Security Classification)
Fiber Coupled Phase Conjugation Mirror and Temporal Information Exchange Using Photorefractive Materials

12. PERSONAL AUTHOR(S)
A. Yariv

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final Report	FROM 9/28/87 TO 9/27/89		

16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
phase conjugation

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Optical phase conjugation has been investigated extensively in many areas of nonlinear optics In particular it is well known that it can be used to correct phase distortions because of the wavefront-reversal properties of an incoming optical wave. For this reason the main emphasis has been on the study of the properties of ordinary phase conjugate mirrors (PCM's) that reflect waves of a particular polarization (usually a linear polarization). In spite of the usefulness of the ordinary PCM's, however, they cannot be applied to the cases where the distortions include optical anistropies by which incident waves suffer from polarization scrambling as well as phase distortions. This is caused, for example, by the induced birefringence in high power optical amplifier stages and by the strong intermodal coupling in multimode fibers. These call for phase conjugation of both polarization components of the beam. We have investigated theoretically and experimentally on polarization and spatial information recovery by modal dispersal and phase conjugation. The scheme, which consists of a tandem combination of a multimode fiber and a photorefractive self-pumped PCM uses the

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21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL

DD Form 1473, JUN 86 Previous editions are obsolete SECURITY CLASSIFICATION OF THIS PAGE

inherent strong intermodal coupling (i.e., modal dispersal) in the fiber combined with phase conjugation of one polarization component of the depolarized (i.e., mode-scrambled) field emitted from the fiber.

Investigation of polarization and spatial information recovery by modal dispersal and phase conjugation

Optical phase conjugation has been investigated extensively in many areas of nonlinear optics. In particular it is well known that it can be used to correct phase distortions because of the wavefront-reversal properties of an incoming optical wave. For this reason the main emphasis has been on the study of the properties of ordinary phase-conjugate mirrors (PCM's) that reflect waves of a particular polarization (usually a linear polarization). In spite of the usefulness of the ordinary PCM's, however, they cannot be applied to the cases where the distortions include optical anisotropies by which incident waves suffer from polarization scrambling as well as phase distortions. This is caused, for example, by the induced birefringence in high power optical amplifier stages, and by the strong intermodal coupling in multimode fibers. These call for phase conjugation of both polarization components of the beam.

We have investigated theoretically and experimentally on polarization and spatial information recovery by modal dispersal and phase conjugation. The scheme, which consists of a tandem combination of a multimode fiber and a photorefractive self-pumped PCM* (see Fig. 1), uses the inherent strong intermodal coupling (i.e., modal dispersal) in the fiber combined with phase conjugation of one polarization component of the depolarized (i.e., mode-scrambled) field emitted from the fiber.

We have found that this scheme permits phase conjugation of an arbitrary polarized wave in spite of the elimination of one polarization component (see Fig. 2). This is because the polarization and spatial information of an input is distributed via the strong intermodal coupling among all the fiber modes, and the surviving single polarization modes contain sufficient information about the missing modes so that the latter are reconstructed during the reverse propagation and the intermodal coupling in the fiber.

The fidelity of this phase conjugation process has also been studied. It is found that the depolarized noise associated with a reconstruction of the original information contains nearly the same amount of the total power as that of the reconstructed true phase-conjugate beam and is distributed among all of the fiber modes, independently of the mode distribution of the original input beam. Therefore the noise power per mode can be negligibly small compared to that of the true phase-conjugate beam for the input-

beam numerical aperture (N.A.) much smaller than the fiber's N.A. This enables the complete recovery of polarization and spatial information.

The concept of modal dispersal and phase conjugation has been applied to a number of novel applications. These include correction of nonreciprocal polarization distortions, correction of lossy amplitude distortions, temporal data channeling between beams, all-optical beam thresholding, and phase-conjugate fiber-optic sensors. There is no doubt, although the scheme may be somewhat limited as far as pictorial information processing is concerned (i.e., when large N.A. inputs are required), it permits new signal processing applications involving sensors, gyroscopes, multichannel switching, and optical interconnections.

* A photorefractive self-pumped PCM is a simple and an efficient PCM but works only for a linearly polarized input.

List of publications resulting from this research

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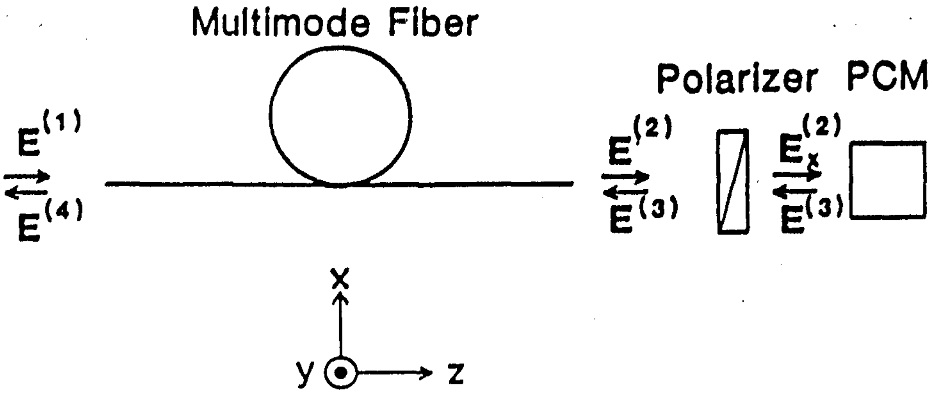

Figure 1. Schematic diagram of the fiber-coupled PCM for polarization and spatial information recovery. The (polarization and modal-scrambling) multimode fiber is assumed to be linear with negligible loss.

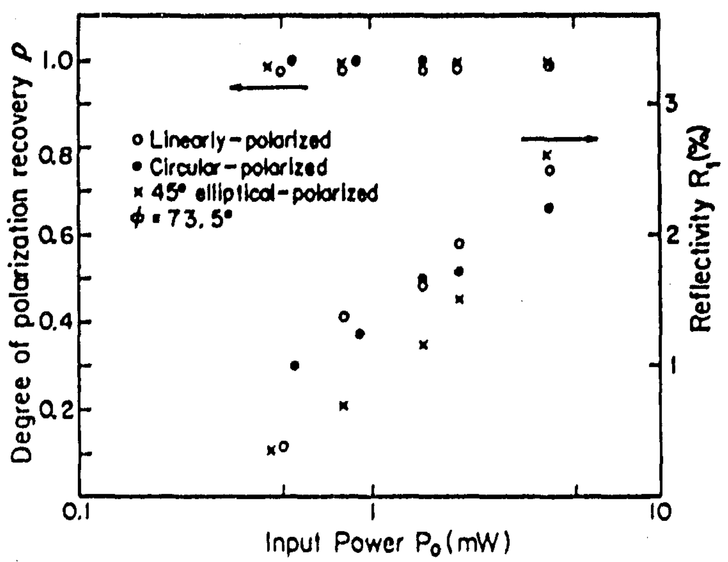

Figure 2. Degree of polarization recovery p and reflectivity R_1 of the fiber-coupled PCM are plotted as a function of the input power P_0 for the three different input polarization states; linearly polarized (o), circularly polarized (•), and 45° elliptically polarized (x).